**Evolution, Origin of Life, and Classification: Standards and Objectives**

Ms. Ottolini, AP Biology, 2013-2014

**Enduring understanding 1.A:** Change in the genetic makeup of a population over time is evolution.

**Essential knowledge 1.A.1:** Natural selection is a major mechanism of evolution.

a. According to Darwin’s theory of natural selection, competition for limited resources results in differential survival. Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.

b. Evolutionary fitness is measured by reproductive success.

c. Genetic variation and mutation play roles in natural selection. A diverse gene pool is important for the survival of a species in a changing environment.

d. Environments can be more or less stable or fluctuating, and this affects evolutionary rate and direction; different genetic variations can be selected in each generation

e. An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.

f. In addition to natural selection, chance and random events can influence the evolutionary process, especially for small populations.

g. Conditions for a population or an allele to be in Hardy-Weinberg equilibrium are: (1) a large population size, (2) absence of migration, (3) no net mutations, (4) random mating and (5) absence of selection. These conditions are seldom met.

h. Mathematical approaches are used to calculate changes in allele frequency, providing evidence for the occurrence of evolution in a population.

To demonstrate understanding of this concept, make sure you can utilize the following:

● Graphical analysis of allele frequencies in a population

● Application of the Hardy-Weinberg equilibrium equation

***Learning Objectives:***

*● The student is able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and to apply mathematical methods and conceptual understandings to investigate the cause(s) and effect(s) of this change.*

*● The student is able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution.*

*● The student is able to apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future.*

**Essential knowledge 1.A.2:** Natural selection acts on phenotypic variations in populations.

a. Environments change and act as selective mechanism on populations.

b. Phenotypic variations are not directed by the environment but occur through random changes in the DNA and through new gene combinations.

c. Some phenotypic variations significantly increase or decrease fitness of the organism and the population.

d. Humans impact variation in other species.

To demonstrate understanding, make sure you can explain examples like:

● Flowering time in relation to global climate change

● Peppered moth

● Sickle cell anemia

● DDT resistance in insects

● Artificial selection

● Loss of genetic diversity within a crop species

● Overuse of antibiotics

***Learning Objectives:***

*● The student is able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time.*

*● The student is able to connect evolutionary changes in a population over time to a change in the environment.*

**Essential knowledge 1.A.3:** Evolutionary change is also driven by random processes.

a. Genetic drift is a nonselective process occurring in small populations.

b. Reduction of genetic variation within a given population can increase the differences between populations of the same species.

***Learning Objectives:***

*● The student is able to use data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and effects of selection in the evolution of specific populations.*

*● The student is able to justify data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and the effects of selection in the evolution of specific populations.*

*● The student is able to make predictions about the effects of genetic drift, migration and artificial selection on the genetic makeup of a population.*

**Essential knowledge 1.A.4:** Biological evolution is supported by scientific evidence from many disciplines, including mathematics.

a. Scientific evidence of biological evolution uses information from geographical, geological, physical, chemical and mathematical applications.

b. Molecular, morphological and genetic information of existing and extinct organisms add to our understanding of evolution.

Evidence of student learning is a demonstrated understanding of each of the following:

1. Fossils can be dated by a variety of methods that provide evidence for evolution. These include the age of the rocks where a fossil is found, the rate of decay of isotopes including carbon-14, the relationships within phylogenetic trees, and the mathematical calculations that take into account information from chemical properties and/or geographical data.

2. Morphological homologies represent features shared by common ancestry. Vestigial structures are remnants of functional structures, which can be compared to fossils and provide evidence for evolution.

3. Biochemical and genetic similarities, in particular DNA nucleotide and protein sequences, provide evidence for evolution and ancestry.

4. Mathematical models and simulations can be used to illustrate and support evolutionary concepts.

To demonstrate understanding, make sure you can do the following:

● Graphical analyses of allele frequencies in a population

● Analysis of sequence data sets

● Analysis of phylogenetic trees

● Construction of phylogenetic trees based on sequence data

***Learning Objectives:***

*● The student is able to evaluate evidence provided by data from many scientific disciplines that support biological evolution.*

*● The student is able to refine evidence based on data from many scientific disciplines that support biological evolution.*

*● The student is able to design a plan to answer scientific questions regarding how organisms have changed over time using information from morphology, biochemistry and geology.*

*● The student is able to connect scientific evidence from many scientific disciplines to support the modern concept of evolution.*

*● The student is able to construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution.*

**Enduring understanding 1.B:** Organisms are linked by lines of descent from common ancestry.

**Essential knowledge 1.B.1:** Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.

1. Structural and functional evidence supports the relatedness of all domains.

Evidence of student learning is a demonstrated understanding of each of the following:

1. DNA and RNA are carriers of genetic information through transcription, translation and replication.

2. Major features of the genetic code are shared by all modern living systems.

3. Metabolic pathways are conserved across all currently recognized domains.

b. Structural evidence supports the relatedness of all eukaryotes.

To foster student understanding of this concept, instructors can choose an illustrative example such as:

○ Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological

integrity and organelle transport)

○ Membrane-bound organelles (mitochondria and/or chloroplasts)

○ Linear chromosomes

○ Endomembrane systems, including the nuclear envelope

***Learning Objectives:***

*● The student is able to pose scientific questions that correctly identify essential properties of shared, core life processes that provide insights into the history of life on Earth.*

*● The student is able to describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms.*

*● The student is able to justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.*

**Essential knowledge 1.B.2:** Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.

1. Phylogenetic trees and cladograms can represent traits that are either derived or lost due to evolution.

To demonstrate understanding, make sure you can explain the following:

● Number of heart chambers in animals

● Opposable thumbs

● Absence of legs in some sea mammals

b. Phylogenetic trees and cladograms illustrate speciation that has occurred, in that relatedness of any two groups on the tree is shown by how recently two groups had a common ancestor.

c. Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species, and from DNA and protein sequence similarities, by employing computer programs that have sophisticated ways of measuring and representing relatedness among organisms.

d. Phylogenetic trees and cladograms are dynamic (i.e., phylogenetic trees and cladograms are constantly being revised), based on the biological data used, new mathematical and computational ideas, and current and emerging knowledge.

***Learning Objectives:***

*● The student is able to pose scientific questions about a group of organisms whose relatedness is described by a phylogenetic tree or cladogram in order to (1) identify shared characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic*

*tree.*

*● The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation.*

*● The student is able create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set.*

**Enduring understanding 1.C:** Life continues to evolve within a changing environment.

**Essential knowledge 1.C.1:** Speciation and extinction have occurred throughout the Earth’s history.

a. Speciation rates can vary, especially when adaptive radiation occurs when new habitats become available.

b. Species extinction rates are rapid at times of ecological stress. [See also 4.C.3]

To demonstrate understanding, make sure you can explain the following:

● Five major extinctions

● Human impact on ecosystems and species extinction rates

***Learning Objectives:***

*● The student is able to analyze data related to questions of speciation and extinction throughout the Earth’s history.*

*● The student is able to design a plan for collecting data to investigate the scientific claim that speciation and extinction have occurred throughout the Earth’s history.*

**Essential knowledge 1.C.2:** Speciation may occur when two populations become reproductively isolated from each other.

a. Speciation results in diversity of life forms. Species can be physically separated by a geographic barrier such as an ocean or a mountain range, or various pre-and post-zygotic mechanisms can maintain reproductive isolation and prevent gene flow.

b. New species arise from reproductive isolation over time, which can involve scales of hundreds of thousands or even millions of years, or speciation can occur rapidly through mechanisms such as polyploidy in plants.

***Learning Objectives:***

*● The student is able to use data from a real or simulated population(s), based on graphs or models of types of selection, to predict what will happen to the population in the future.*

*● The student is able to justify the selection of data that address questions related to reproductive isolation and speciation.*

*● The student is able to describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift.*

**Essential knowledge 1.C.3:** Populations of organisms continue to evolve.

a. Scientific evidence supports the idea that evolution has occurred in all species.

b. Scientific evidence supports the idea that evolution continues to occur.

To foster student understanding of this concept, make sure you can explain the following:

● Chemical resistance (mutations for resistance to antibiotics, pesticides, herbicides or chemotherapy drugs occur in the absence of the chemical)

● Emergent diseases

● Observed directional phenotypic change in a population (Grants’ observations of Darwin’s finches in the Galapagos)

● A eukaryotic example that describes evolution of a structure or process such as heart chambers, limbs, the brain and the immune system

***Learning Objectives:***

*● The student is able to describe a model that represents evolution within a population.*

*● The student is able to evaluate given data sets that illustrate evolution as an ongoing process.*

**Enduring understanding 1.D:** The origin of living systems is explained by natural processes.

**Essential Knowledge 1.D.1:** There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.

1. Scientific evidence supports the various models.

Evidence of student learning is a demonstrated understanding of each of the following:

1. Primitive Earth provided inorganic precursors from which organic molecules could have been synthesized due to the presence of available free energy and the absence of a significant quantity of oxygen.

2. In turn, these molecules served as monomers or building blocks for the formation of more complex molecules, including amino acids and nucleotides.

3. The joining of these monomers produced polymers with the ability to replicate, store and transfer information.

4. These complex reaction sets could have occurred in solution (organic soup model) or as reactions on solid reactive surfaces.

5. The RNA World hypothesis proposes that RNA could have been the earliest genetic material.

***Learning Objectives:***

*● The student is able to describe a scientific hypothesis about the origin of life on Earth.*

*● The student is able to evaluate scientific questions based on hypotheses about the origin of life on Earth.*

*● The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth.*

*● The student is able to evaluate scientific hypotheses about the origin of life on Earth.*

*● The student is able to evaluate the accuracy and legitimacy of data to answer scientific questions about the*

*origin of life on Earth.*

**Essential knowledge 1.D.2:** Scientific evidence from many different disciplines supports models of the origin of life.

1. Geological evidence provides support for models of the origin of life on Earth.

Evidence of student learning is a demonstrated understanding of each of the following:

1. The Earth formed approximately 4.6 billion years ago (bya), and the environment was too hostile for life until 3.9 bya, while the earliest fossil evidence for life dates to 3.5 bya. Taken together, this evidence provides a plausible range of dates when the origin of life could have occurred.

2. Chemical experiments have shown that it is possible to form complex organic molecules from inorganic molecules in the absence of life.

b. Molecular and genetic evidence from extant and extinct organisms indicates that all organisms on Earth share a common ancestral origin of life.

Evidence of student learning is a demonstrated understanding of each of the following:

● Scientific evidence includes molecular building blocks that are common to all life forms.

● Scientific evidence includes a common genetic code.

***Learning Objective:***

*● The student is able to justify the selection of geological, physical, and chemical data that reveal early Earth conditions.*

**Evolution, Origin of Life, and Classification: Objectives Cheat Sheet**

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**What resources did I use to learn this information and/or master this skill?**

1. You will be able to define evolution and describe how natural selection causes evolution based on various sources of evidence *(EK 1.A.1, 1.A.2, 1.A.4, 1.C.3)*
2. You will be able to describe the conditions that must be met for a population to stop evolving, and use equations to predict current and future allele, genotype, and phenotype frequencies in the population. *(EK 1.A.1, 1.A.3)*
3. You will be able to interpret evidence indicating speciation and extinction events throughout Earth’s history and identify potential causes for speciation in a population. *(EK 1.C.1, 1.C.2)*
4. You will be able to analyze and create phylogenetic trees and cladograms to determine relatedness between groups of organisms. *(EK 1.B.2)*
5. You will be able to describe the current hypotheses regarding the origin and history of living organisms and evaluate their validity based on observational and experimental evidence. *(EK 1.B.1, 1.D.1, 1.D.2)*